The Effect of Shortening Lock-in Periods in Telecommunication Services

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Abstract

We study the welfare implications of shortening the length of the lock-in period associated to triple play contracts using household level data for a period of 6 months from a large telecommunications provider. Using a multinomial logit model to explain consumer behavior we show that, in our setting, shortening the length of the lock-in period decreases the aggregated profit of the firms in the market more than it increases consumer surplus. This result arises because shortening the length of the lock-in period increases churn and the costs to set up service for the consumers that churn and join a new carrier supersede the increase in the consumers' willingness to pay for service when the length of the lock-in period reduces. We also show that, in our setting, consumers are worse off with shorter lock-in periods if firms react by increasing prices to keep their profits. Therefore, regulators that introduce policies to shorten the length of lock-in periods may also need to consider policies that prevent firms from increasing prices (too much) in order to improve consumer well-being.

1 Introduction

In industries where customer acquisition is costly firms typically opt for subscription-based business models locking-in consumers into long-term contracts. These contracts, often termed lock-in periods in the industry, aim at ensuring that consumers stay with the firm enough time so that the cumulative of their monthly bills over their tenure covers not only the costs with maintenance and service provision but also the initial costs associated to consumer acquisition and service deployment / activation (Farrell and Klemperer, 2007)[1].

In this type of markets, consumers can still terminate contracts before lock-in periods are over. However, to do so, they need to pay a financial penalty as established in the contract with the firm. These penalties are typically set in a way that allows firms to cover the costs incurred to set up service when customers join. Starting in the early 2000s, in the telecommunications sector, several firms offered contracts that locked-in consumers for long periods of time. For example, in the UK, Orange encouraged customers to sign up contracts with 24-month lock-in periods (Capgemini, 2009). In Canada, Rogers Communications, BCE, and Telus, offered contracts with 3-year lock-in periods for mobile phone service (CRTC, 2012). Mobile firms in Asian countries such as South Korea, Japan and China also offered contracts with 24-month lock-in periods around the same time.

From 2011 onwards there has been a regulatory push to shorten lock-in periods in telecommunications all around the world. In the EU, the Telecommunications Law banned 3-year long contracts by limiting the maximum lock-in period to 24 months (European-Union, 2009). Other regions followed a similar approach. For example, in 2013, the Canadian

[1]Examples of industries that share these characteristics include telecommunications, home security and surveillance, and several utilities where there is a need to deploy equipment at the consumer's premises to allow accessing and measuring the service that is provided (e.g. electricity, water)

Radio-television and Telecommunications Commission (CRTC) limited lock-in periods to 24 months and capped early cancelation fees to the subsidy provided by firms for device acquisition (CRTC, 2013). More recently, in the US, President Obama signed the "Unlocking Consumer Choice and Wireless Freedom Act" requiring US carriers to unlock devices when customers request, thus allowing them to keep the same handset when switching provider (Congress, 2013). The debate about lock-in periods has reignited again in recent times in countries such as the United Kingdom, Canada and Denmark and many regulators are now considering reducing these periods even further.

Lock-in periods are a particular case of switching costs and thus may hurt consumers because they reduce their freedom to choose service provider (Klemperer, 1987, 1995). However, a number of complex dynamic factors render the effect of switching costs on consumer surplus hard to predict (Dubé et al., 2009; Villas-Boas, 2015). For example, when firms cannot exploit existing consumers they are less likely to compete for them in the first place, which may increase prices and thus reduce consumer surplus (Cabral, 2009). These complex dynamics suggest that measuring the impact of switching costs on welfare is essentially an empirical question, to which our study contributes by estimating how shortening lock-in periods to less than the current status quo of 24 months affects welfare, that is, how such a change may affect both consumer surplus and firm profit. We focus on a market for triple-play services, which is now dominant mode to consume telecommunications and media services both in the US and in the EU (OVUM, 2015).

Our paper uses a dataset from a large triple-play telecommunications provider to study what happens to consumers and firms when the lock-in period reduces. We use this dataset to estimate a multinomial logit model in which households can choose to keep the same service, change service inside the carrier or churn. This model allows us to measure switching costs in dollar terms as well as simulate how changes in the length of the lock-in period affect both consumers and firms. In our empirical context, and for when two firms compete, we find that the average switching cost to change service inside the firm is $162 whereas the average switching cost associated to churn is above $210 and increases roughly $1 per additional month of outstanding lock-in. More important, we also find that firms lose more profit than what consumers gain in surplus when lock-in periods reduce. For example, in our empirical context, and again for when two firms compete, the average consumer surplus increases less than $16 if the lock-in period reduces from 24 to 16 months. However, the profits that the firms in the market collect from that representative consumer decrease more than $25, showing that reducing the lock-in period reduces welfare. Similar results are obtained for different numbers of players in the market and for different reductions in the length of the lock-in period lending robustness to our findings.

Our paper offers several unique contributions. First, we measure switching costs inside and outside the firm in dollar terms over the same time window, allowing us to compare them appropriately. Second, we show that regulators need to be very careful when considering shortening lock-in periods. Doing so increases consumer surplus but reduces firm profits and, as is usually the case, regulators need to ponder between these two opposing forces in a way that provides consumers flexibility but that also ensures that carriers have sufficient incentive to be in business and maintain, or even upgrade, the quality of the services that they provide provided. Third, our paper also shows that consumers become worse-off if firms react to shorter lock-in periods by increasing prices to keep their profits, that is, if firms do so then consumers would be better off if lock-in periods would not have been reduced. This result shows that regulators may need to combine reductions in lock-in periods with policies that cap prices to achieve the desired goals, otherwise their interventions can easily backfire. These insights are likely to provide great value to regulators around the world now that a number of them are looking at changing lock-in policies.

The remainder of our paper is organized as follows. Section 2 reviews the related work. Section 3 describes our empirical context and provides descriptive statistics. Section 4 introduces our model. Section 5 presents our estimates of switching costs and section 6 describes several policy simulations studying the effect of shortening lock-in periods on consumer surplus and firm profits. Section 8 summarizes our work and concludes.

2 Literature Review

Our paper is related to the empirical literature that measures switching costs and thus it is closely linked to the active monitoring of switching costs performed by National Regulatory Authorities (NRAs). NRAs oversee switching costs and suggest legislation that Governments may enforce to limit them. This is a complex task because regulators have to consider the trade-off between consumer surplus and welfare, the latter defined as the sum of the former and firm profits. The regulator's task is not just one of fairly splitting welfare between consumers and firms but also one of looking for ways to maximize overall well-being (Gans, 2001). Conventional wisdom suggests that low switching costs are likely to increase consumer surplus (Klemperer, 1995). Market leaders tend to enjoy significant advantages when switching costs are high, allowing them to sustain large market shares and thus charge relatively high prices (Lieberman and Montgomery, 1998; Bijwaard et al., 2008). With high switching costs entrants also have a hard time to steal consumers that are locked-in to the market leader even if they offer better prices. In short, high switching costs allow firms, and market leaders in particular, to exploit consumers that are locked-in by charging them higher prices, a strategy called bargain-then-rip-off (Klemperer, 1987, 1995), which has been extensively documented using empirical data (Sharpe, 1997; Shy, 2002; Stango, 2002; Viard, 2007).

However, and at the same time, low switching costs provide little incentive for firms to provide service in the first place, which may reduce both consumer surplus and welfare (Farrell and Klemperer, 2007). Low switching costs may result in other adverse effects for consumers (Cabral, 2009). For example, when firms cannot exploit existing consumers, they have little incentive to attract them in the first place (Dubé et al., 2009; Shin and Sudhir, 2008; Doganoglu, 2010), which may result in higher starting prices for consumers. Additionally, in markets where switching generates additional setup costs, low switching costs leading to more frequent switching generate more of such costs rendering the market less efficient (Gans, 2001).

The theory of switching costs is rich in economic theoretical models. However, papers measuring these costs empirically are far scarcer. Exceptions include Borenstein (1991) who measured switching costs in the US retail gasoline market, Knittel (1997) who showed how the presence of significant switching costs led to little change in the prices of long distance phone calls in the US after the divestiture of AT&T in 1984, Viard (2007) who studied the introduction of number portability for toll-free numbers in the US and found that switching costs had an ambiguous effect on prices for firms that could not discriminate between existing and new consumers, Epling (2002) who studied competition in long distance telephony in the US after the Telecom Act of 1996 and found that consumers subject to higher switching costs paid higher prices and Grzybowski (2008) who found significant switching costs in the mobile sector in the UK after the turn of the century. Using a discrete choice experiment in a European country, Confraria et al. (2017) found that consumers were willing to pay 1.3 Euros per month to reduce the lock-in period associated to their cellphone service from 12 to 6 months. Closer to our work, Shcherbakov (2016) studied switching costs in the TV industry in the US between 1997 and 2006. The author found that these costs amounted to $200 and $244 for cable and satellite systems, respectively. These estimates are close to the ones we find in our paper.

3 Empirical Context

We use a transactional dataset from a large telecommunications triple-play provider (hereinafter called TELCO) covering the period between April and October 2013. TELCO is a major provider of telecommunication services in the country that we analyze. The penetration of triple play service in this country is above 70% and in 2013, about 70% of TELCO customers subscribed triple-play service. The triple play service that TELCO provides includes TV, Internet and fixed telephony. For each household and each month, our dataset contains information on the services subscribed and prices charged. For each bundle of services offered by TELCO we have bundle-specific characteristics such as the number of TV channels, the maximum Internet speed, premium features (such access to Video-on-Demand), and whether mobile service was included. We also obtained information on the service bundles that were provided by TELCO competitors in the zip-code where each household served by TELCO was located. We know how many providers offer each bundle and the lowest price charged for it.

Finally, this dataset includes household level covariates such as contract details, including the length of the lock-in period and the number of months that elapsed since the household subscribed each service, and information on the monthly usage of the services contracted, such as Internet traffic (amount of uploads and downloads) and the number of landline calls placed and received. We obtained data for a random sample of 100,000 triple-play households of which we discarded 2,772 for which information on the services contracted was unavailable. Table 1 summarizes the service bundles that TELCO offered in 2013. They differ in the number of TV channels offered, Internet speeds and whether advanced features to watch TV were available. For example, bundles marked premium offered advanced features such as video-recording and Video-on-Demand. One bundle offered mobile service. This table reports the average price charged for each bundle alongside its standard deviation. The same bundle may be charged different prices to different households depending, for example, on when each household signed up, the negotiation between the household and the firm, and marketing campaigns.

The *best price* column in this table provides information on the lowest available introductory price for each bundle. This statistic was calculated from the information available about the offers extended by TELCO's competitors in each household's zip code. During our period of analysis, the average number of service provides per zip-code was 2.88 and the median was 3.

XXX TABLE 1 HERE XXX

During our period of analysis consumers could change service bundle inside TELCO or churn. A consumer whose lock-in period ends commits to a 12-month lock-in period when she changes service bundle inside TELCO. A consumer that is more than 12 months away from lock-in expiry experiences no change in the lock-in if she changes service bundle inside TELCO. A consumer who is less than 12 months away from lock-in expiry gets her lock-in period reset to 12 months if she changes service bundle inside the carrier. New consumers always face a lock-in period of 24 months. If a consumer switches provider then a lock-in period of 24 months is enforced by the new provider. Between April and October 2013, and on average per month, around 1% of TELCO consumers churn, 4% of them change service bundle inside TELCO and 1% are new to TELCO.

Figure 1 shows the density of changes inside TELCO and churn as a function of time to lock-in expiry. The x-axis shows the number of months to lock-in expiry. Negative values indicate the number of months elapsed after the lock-in period expired. Rates of change in these figures are small within the first 12 months of a 24-month lock-in period. Otherwise, change happens when lock-in periods expire, in particular significant churn occurs around month 24. Sometimes, consumers churn when there is still 1 month to lock-in expiry because competitors cover this financial penalty to steal consumers from competitors (by offering consumers a few months of service for free). Changes of service bundle inside TELCO happen within the second half of a 24-month lock-in period. A peak of changes within TELCO occurs at around 10 months into the lock-in period, which may be related to TELCO's proactive marketing strategies that are, in part, aimed at ensuring that lock-in periods remain far from expiry. During our period of analysis, 54% of the households in our sample were within a lock-in period. Furthermore, during our period of analysis, all major service providers that compete with TELCO offered contracts similar to those offered by TELCO.

XXX FIGURE 1 HERE XXX

4 Model

We follow the approach laid out in figure 2 to study the impact of changing lock-in periods on consumer surplus and on firm profit. First, we use the dataset that TELCO provided us to estimate the demand for the different service bundles that consumers can choose from at any point in time. We use discrete choice models to do so. Second, we use the results from these models to simulate churn rates and consumer surplus as a function of how the length of the lock-in period changes. Finally, firm profits are determined using the predicted market shares for the different products, their prices and the rates of churn predicted by our model, which allows us to compute revenue flows over the expected lifetime of consumers with TELCO.

XXX FIGURE 2 HERE XXX

In the next subsections we provide a detailed overview of how we model consumer behavior, firm profit, consumer surplus and welfare.

4.1 The Consumers' Choice Model

We model household behavior using a multinomial logit model. In this model, households choose among $J + 2$ alternatives: J triple play bundles at TELCO (denoted as options 1 through J), an option to downgrade service by choosing a non-triple-play bundle at TELCO [2], or churn (denoted by option $J + 2$). When a household churns we assume that she

[2]TELCO offered several non-triple play bundles during our period of analysis, namely "TV-only", "TV+Internet", and "TV+Voice". In our data, 0.9% of the triple play households move to such a bundle.

subscribes a similar service bundle from a competitor at a lower price. The prices offered by competitors are set as described in section 3. In this setting, the utility of household h from choosing alternative j at time t, represented by u_{hj}^t, is given by:

$$u_{hj}^t(\mathbf{X_j}, p_{hj}^t, \mathbf{a_h^{t-1}}, \mathbf{z_h^t}, l_h^t, L_{hj}^t) = V_{hj}^t(\mathbf{X_j}, p_{hj}^t, \mathbf{a_h^{t-1}}, \mathbf{z_h^t}, l_h^t, L_{hj}^t) + \epsilon_{hj}^t \tag{1}$$

where $V(\cdot)$ represents the observable part of utility, which depends on a vector of bundle-specific characteristics $\mathbf{X_j}$, the monthly bill p_{hj}^t, the household's choice of service bundles up to the previous time period $\mathbf{a_h^{t-1}} = \{a_h^1, ..., a_h^{t-1}\}$ where a_h^τ represents the choice of household h at time τ, a vector of demographic time-varying characteristics $\mathbf{z_h^t}$, the remaining lock-in period l_h^t and the original length of the last lock-in period (potentially the current one if still active), L_{hj}^t. ϵ_{hj}^t represents the idiosyncratic error term, which we assume follows an i.i.d. Type I extreme value distribution. The probability that household h chooses alternative j at time t, is given by:

$$P(a_h^t = j \mid \{\mathbf{X_j}, p_{hj}^t, \mathbf{a_h^{t-1}}, \mathbf{z_h^t}, l_h^t, L_{hj}^t\}_{j=1}^{J+2}) = \frac{\exp u_{hj}^t(\mathbf{X_j}, p_{hj}^t, \mathbf{a_h^{t-1}}, \mathbf{z_h^t}, l_h^t, L_{hj}^t)}{\sum_{k=1}^{J+2} \exp u_{hk}^t(\mathbf{X_h}, p_{hk}^t, \mathbf{a_h^{t-1}}, \mathbf{z_h^t}, l_h^t, L_{hk}^t)} \tag{2}$$

We use a linear functional form for $V(\cdot)$ to estimate switching costs both to change bundle inside TELCO as well as to churn. For this purpose, we define:

$$
\begin{aligned}
V_{hj}^{t}(\mathbf{X_j}, p_{hj}^{t}, \mathbf{a_h^{t-1}}, \mathbf{z_h^t}, l_h^t, L_h^t) =& \mathbf{X_j}\alpha - \beta p_{hj}^{t} + \mathbf{z_h^t}\mu_j - \gamma_1 C_{hj}^{t} I_j \\
& + \gamma_2 C_{hj}^{t} O_j \mathbb{1}(l_h^t \leq 1) + \gamma_3 C_{hj}^{t} O_j \mathbb{1}(l_h^t > 1) + \gamma_4 C_{hj}^{t} O_j \mathbb{1}(l_h^t > 1) l_h^t \\
& + \gamma_5 C_{hj}^{t} O_j \mathbb{1}(l_h^t \leq 1) L_{hj}^t + \gamma_6 C_{hj}^{t} O_j \mathbb{1}(l_h^t > 1) L_{hj}^t \\
& + \gamma_7 C_{hj}^{t} O_j \mathbb{1}(l_h^t \leq 1) Tenure_h^t + \gamma_8 C_{hj}^{t} O_j \mathbb{1}(l_h^t > 1) Tenure_h^t \\
& + \gamma_9 C_{hj}^{t} I_j N_h^t + \gamma_{10} C_{hj}^{t} O_j \mathbb{1}(l_h^t \leq 1) N_h^t + \gamma_{11} C_{hj}^{t} O_j \mathbb{1}(l_h^t > 1) N_h^t
\end{aligned} \tag{3}
$$

where $I_j = \mathbb{1}(j \neq "churn")$ and $O_j = \mathbb{1}(j = "churn")$ indicate whether alternative j is a bundle inside TELCO or churn, respectively. $C_{hj}^t = \mathbb{1}(a_h^{t-1} \neq j)$ indicates whether household h changes service bundle at time t. $Tenure_h^t$ indicates the tenure of household h at time t with TELCO and $\mathbf{z_h^t}\mu_j$ represent interactions between household characteristics and dummies for each alternative. Additionally, N_h^t represents the number of TELCO competitors in the zip-code where household h is located that offer a service similar to that currently subscribed by household h. All coefficients in this expression have economic meaning and their ratio to β provide interpretations in dollar terms. Table 2 describes these coefficients, their meaning and the signs that we expect to empirically observe.

XXX TABLE 2 HERE XXX

4.2 Churn rates, Consumer Surplus and TELCO Profits

Churn rates are determined by the market share of the churn alternative in the multinomial choice model introduced above. The consumer surplus of the representative household is determined the utility provided by the best alternative available to her, that is:

$$CS_h^t(\{\mathbf{\Gamma^t_{hj}}, L_{hj}^t\}_{j=1}^{J+2}) = \frac{1}{\beta} \max_{j=1,...J+2} \{u_{hj}^t(\mathbf{\Gamma^t_{hj}}, L_{hj}^t)\} \tag{4}$$

$$E[CS_h^t(\{\mathbf{\Gamma^t_{hj}}, L_{hj}^t\}_{j=1}^{J+2})] \approx \frac{1}{\beta} \ln(\sum_{j=1}^{J+2} \exp(V_{hj}^t(\mathbf{\Gamma^t_{hj}}, L_{hj}^t))) + C \tag{5}$$

where, for sake of space, $\mathbf{\Gamma^t_{hj}} = (\mathbf{X_j}, p_{hj}^t, \mathbf{a_h^{t-1}}, \mathbf{z_h^t}, l_h^t)$ and h denotes the representative household and the approximation for the expected value is obtained from integrating over the distribution of the error term. In this model, C is an unknown constant that is irrelevant for comparison purposes and therefore usually ignored for policy analysis (Train, 2009). The expected cumulative surplus of the representative household is therefore given by

$$E[CS_h(\{\mathbf{\Gamma^t_{hj}}, L_{hj}^t\}_{j=1}^{J+2})] = \sum_{t=0}^{\infty} \frac{E[CS_h^t(\{\mathbf{\Gamma^t_{hj}}, L_{hj}^t\}_{j=1}^{J+2})]}{(1+\delta)^t} A_h^t(\{\mathbf{\Gamma^t_{hj}}, L_{hj}^t\}_{j=1}^{J+2}) \tag{6}$$

$$A_h^t(\{\mathbf{\Gamma^t_{hj}}, L_{hj}^t\}_{j=1}^{J+2}) = \prod_{\tau=0}^{t-1} 1 - P(a_h^t = "churn" \mid \{\mathbf{\Gamma^t_{hj}}, L_{hj}^t\}_{j=1}^{J+2}) \tag{7}$$

where $A_h^t(\cdot)$ represents the survival probability of household h at time t and δ represents this household's monthly discount rate.

TELCO profits are given by the difference between the discounted revenues obtained from providing service to the representative household and the cost to acquire her and set up service to her. The latter is represented below by $AC_{TELCO,h}$. These costs are incurred by TELCO at the beginning of each contract and include capital cost with equipment, such as Internet modems and set-top-boxes, and costs to deploy it at the customer premises, which usually requires a visit from a specialized technician. The discounted future revenues of TELCO include expected revenues from providing service to the representative household, denoted below by $\Pi^{MP}_{TELCO,h,t}$ for month t, and expected penalties collected when she terminates service before the lock-in period expires, denoted below by $\Pi^{Pen}_{TELCO,h,t}$ for month t, and are thus given by:

$$\Pi_{TELCO,h}(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}_{j=1}^{J+2}) = \sum_{t=0}^{\infty} \frac{\Pi^{MP}_{TELCO,h,t}(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}_{j=1}^{J+2}) + \Pi^{Pen}_{TELCO,h,t}(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}_{j=1}^{J+2})}{(1+r)^t} - AC_{TELCO,h} \tag{8}$$

where r denotes TELCO's Rate of Return (RoR). TELCO's expected revenues from household h in month t are determined by:

$$\Pi^{MP}_{TELCO,h,t}(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}_{j=1}^{J+2}) = \sum_{k=1}^{J+1} s^t_k (p^t_{hk} - c^t_{hk}) A^t_h(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}_{j=1}^{J+2}) \tag{9}$$

where $s^t_k(a^t_h) = P(a^t_h = k)$ represents the (within TELCO) market share of alternative k and c^t_{hk} represents the marginal operational cost of this alternative for household h. Expected revenues from the financial penalties collected at month t are determined by:

$$\Pi^{Pen}_{TELCO,h,t}(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}_{j=1}^{J+2}) = \sum_{k=1}^{J+1} s^{t-1}_k \mathbb{1}(L^t_{hj} - t \geq 1) p^{t-1}_{hk} (L^t_h - t) B^t_h(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}_{j=1}^{J}) \tag{10}$$

where $B^t_h(\cdot)$ denotes the probability of churn of household h at time t from TELCO, which is given by:

$$B^t_h(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}_{j=1}^{J+2}) = P(a^t_h = \text{``}churn\text{''} \mid \{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}_{j=1}^{J+2}) \prod_{\tau=0}^{t-1} 1 - P(a^\tau_h = \text{``}churn\text{''} \mid \{\mathbf{\Gamma^\tau_{hj}}, L^\tau_{hj}\}_{j=1}^{J+2}) \tag{11}$$

4.3 The Effect of Changing the Length of the Lock-in Period

Throughout this section we assume that changes in the length of the lock-in period are applied to all service bundles and to every carrier in our market equally. This is a reasonable assumption given that the law governing lock-in periods is always a market level policy enforced by each country's National Regulatory Agency (or in the case of Europe by a Directive from the European Commission that each country's Government must transpose to national law). We also assume that when a household churns because the length of lock-in period reduces she subscribes service at a competitor in our market. This is a reasonable assumption in today's telecommunication markets because the level of household penetration of telecommunication services has remained unchanged in most developed countries for a number of years now (STATISTAa, 2017; STATISTAb, 2017; STATISTAc, 2017). In particular, in the country that we analyze roughly 90% of the households subscribe telecommunications services for more than six years. In fact, we assume that when a household churns because the length of lock-in period reduces she subscribes a service at a competitor similar to the one she used to subscribe before she churned. This is a reasonable assumption in today's telecommunication markets because triple-play providers tend to compete by offering similar services.

A reduction in the length of the lock-in period (L_{hj}^t) of m months (to $L_{hj}^t - m$) changes the monthly payments collected by TELCO as well as the revenues associated to contract breaches. The change in TELCO's profit is therefore given by:

$$\Delta\Pi_{TELCO,h}(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}_{j=1}^{J+2}, m) = \sum_{t=0}^{\infty} \frac{\Delta\Pi^{MP}_{TELCO,h,t}(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}_{j=1}^{J+2}, m) + \Delta\Pi^{Pen}_{TELCO,h,t}(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}_{j=1}^{J+2}, m)}{(1+r)^t} \tag{12}$$

$$\Delta\Pi^{MP}_{TELCO,h,t}(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}^{J+2}_{j=1}, m) = \Pi^{MP}_{TELCO,h,t}(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}^{J+2}_{j=1}) - \Pi^{MP}_{TELCO,h,t}(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj} - m\}^{J+2}_{j=1}) \tag{13}$$

$$\Delta\Pi^{Pen}_{TELCO,h,t}(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}^{J+2}_{j=1}, m) = \Pi^{Pen}_{TELCO,h,t}(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}^{J+2}_{j=1}) - \Pi^{Pen}_{TELCO,h,t}(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj} - m\}^{J+2}_{j=1}) \tag{14}$$

Households are likely to churn earlier when the length of the lock-in period reduces. Therefore, both $\Delta\Pi^{MP}_{TELCO,h}$ and $\Delta\Pi^{Pen}_{TELCO,h}$ are negative in this model. Let f represent the firm (TELCO's competitor) capturing a household that churns from TELCO. When the length of the lock-in period reduces by m months the profits of firm f changes according to:

$$\Delta\Pi_{f,h}(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}^{J+2}_{j=1}, m) = -\sum_{t=0}^{\infty} \frac{\Delta\Pi^{MP}_{f,h,t}(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}^{J+2}_{j=1}, m) + \Delta\Pi^{Pen}_{f,h,t}(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}^{J+2}_{j=1}, m)}{(1+r)^t} - \Delta AC_{f,h} \tag{15}$$

where the minus sign denotes the fact that contrary to TELCO firm f captures, instead of loses, household h. Note that in this case, firm f incurs $AC_{f,h}$ when household h churns because in this case she needs to set up service for her (on the contrary, TELCO does not incur this cost because it loses, instead of acquires, household h). We compute what happens at the market level by adding up expression 12 to expression 15, which together allow us to determine what happens to the profits of the firms when the length of the lock-in period reduces, and to expression 16 below, which determines how a reduction of m months in the length of the lock-in period changes the consumer surplus of the representative household:

$$\Delta E[CS_h(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}^{J+2}_{j=1}, m)] = E[CS_h(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj}\}^{J+2}_{j=1}) - E[CS_h(\{\mathbf{\Gamma^t_{hj}}, L^t_{hj} - m\}^{J+2}_{j=1}) \tag{16}$$

Finally, and to build some intuition about how shortening lock-in periods may affect market welfare, consider a household h that does not churn from TELCO because the length of the lock-in period reduces (from L_{hj}^t to $L_{hj}^t - m$). In this case, both $\Delta\Pi_{TELCO,h,t}^{MP}$ and $\Delta\Pi_{f,h,t}^{MP}$ are zero and thus this household's willingness to pay for service at TELCO increases only because with a shorter lock-in period she can churn earlier from TELCO without paying a financial penalty.

Consider now a household h that churns from TELCO because the length of the lock-in period reduces. Assuming that such a household subscribes a service at firm f similar to the service that she used to subscribe at TELCO before she churned implies that $\Delta\Pi_{TELCO,h,t}^{MP}$ is similar to $\Delta\Pi_{f,h,t}^{MP}$ and thus these terms roughly cancel out at the market level. Furthermore, this assumption also implies that this household's willingness to pay for this service at firm f must be roughly similar to her willingness to pay for the service that she used to subscribe at TELCO before the length of lock-in period changed except for the fact that now with a shorter lock-in period she can churn earlier from TELCO without paying a financial penalty.

On the cost side, firm f incurs the acquisition and setup cost when household h churns ($AC_{f,h}$). Therefore, the difference between the increase in the households' willingness to pay for service because the length of the lock-in period reduces (which allows them to churn earlier without paying a financial penalty) and the costs to acquire and set up service for the households that churn because the length of the lock-in period reduces determines the change in welfare triggered by the reduction in the length of the lock-in period, which we compute later in our simulations to evaluate the effect of the policy at the market level.

5 Switching Costs Estimates

Table 3 shows the empirical results obtained from applying the multinomial logit model described in the previous section to our dataset. Column (1) corresponds to equation (3) while columns (2) and (3) provide robustness checks. As expected, γ_1, γ_2 and γ_3 are all negative indicating that switching costs reduce the probability of switching. The results in column (1) show that in a market with two service providers (TELCO and one competitor), if the lock-in period is over, the average switching cost associated to churn is \$210.1 ((-8.62+0.215)/-0.04). Furthermore, this statistic reduces by \$5.4 (0.215/-0.04) per additional competitor in the market. In the last month of the lock-in period, the average switching cost to churn is \$212.6 ((-8.73+0.227)/-0.04). This statistic reduces by \$5.7 (0.227/-0.04) per additional competitor and increases by \$0.95 (-0.037/-0.040) per additional month outstanding in an active lock-in period. The average switching cost to change service bundle inside TELCO in a market with two service providers is \$161.9 ((-6.60+0.122)/-0.04). In this case, one more competitor reduces this statistic by \$3.1 (0.122/-0.04).

Column (2) interacts (standardized versions of) household demographic characteristics with product dummies to control for potential demographic effects. The demographic variables available to us are the age of the account holder and the household's intensity of usage for Internet and voice services. All estimates in this column are quantitatively similar to those shown in column (1). Finally, column (3) provides a model-based check for the assumption of Independence of Irrelevant Alternatives (IIA) that is implicit in multinomial logit models (Keane, 1992). We compare our results using the multinomial logit model to those obtained using a mixed logit model which does not impose IIA (Cheng and Long, 2007). The results in column (3) are qualitatively similar to those reported in columns (1) and (2), thus providing strong evidence that the models in these columns are unlikely to violate the IIA assumption. Therefore, we rely on the model in column (1) to carry out our policy simulations in section 6 given that this model is computationally tractable while the mixed logit is not.

XXX TABLE 3 HERE XXX

6 Policy Simulations

We now study how shortening the length of the lock-in period changes consumer behavior and thus affects market outcomes. We measure expected profits and consumer surplus using the expressions introduced in section 4 and we show how these statistics change relative to the status quo of 24-month lock-in periods. We use $390 (in 2013 USD) as the average the cost incurred by firms in our market to acquire consumers and set up service ($AC_{f,h}$ in our model). This statistic was provided to us by TELCO and includes the cost of the equipment installed at that consumer premises and the cost associated to the trip of the technical team to the customer premises to install and activate the service. Appendix A.1 summarizes the changes in churn rates that we obtain when we use the multinomial choice model introduced in section 4.1 to simulate what happens when the length of the lock-in period change. These changes are used to run the simulations presented below.

6.1 Simulation Results with Prices Unchanged

Figure 3 shows the results that we obtain from our first set of simulations in which we assume that firms do not change prices when the length of the lock-in period reduces. The top left plot shows $\Delta\Pi^{MP}_{TELCO,h}$ as a function of the reduction in the length of the lock-in period. Likewise for the top right plot with respect to $\Delta\Pi^{Pen}_{TELCO,h}$. The bottom left plot adds the former two plots, thus reporting $\Delta\Pi_{TELCO,h}$, and the bottom right plot shows $\Delta E[CS_h]$ as a function of the reduction in the length of the lock-in period. This figure shows TELCO's profits using 3 different levels for the yearly Rate of Return (RoR), which were set around the typical rates experienced in the telecommunication sector (9%, 11% and 13% according to data from Damodaran (2015)). Consumer surplus is also computed using 3 different levels of discount rates. In this case, we surveyed the literature to determine how much households discount the future when they decide to subscribe services similar to triple-play, which lead to selected discount rates ranging from 0.075 to 3.76 [3].

These simulations show that, when firms do not change prices, shortening the length of the lock-in period reduces TELCO's profits and increases consumer surplus. For example, in a market with TELCO and 3 additional service providers, when the lock-in period reduces to 16 months, the present value of the expected consumer surplus for the representative household increases \$2 $\sim$ \$22, depending on the consumer discount rate. The net present value of the expected profits that TELCO enjoys from such a household reduces more than \$50. This loss in profit amounts to 1.5% of the expected present value of the profits that TELCO would obtain if the length of the lock-in period remained at 24 months. The results that we obtain for TELCO profits are qualitatively similar for different rates of return. As for consumer surplus, and as expected, higher discount factors are associated

[3] In a very influential paper, Hausman (1979) found that consumers exhibit a discount rate of about 20%/year for energy-using durable goods. More recently, Yao et al. (2012), using cellphone data from China, reported discount factors between 10%/year and 16%/year (recall that discount factor=1/(1+discount rate). In light of these estimates, we show results for yearly discount rates between 0.075 and 3.762 (corresponding to discount factors between 0.93 and 0.21)

with smaller changes in expected consumer surplus when the length of the lock-in period shortens because the future benefits that consumers obtain from such a reduction become substantially atenuated.

Figure 4 shows how a reduction in the length of the lock-in period affects profits and welfare at the market level. The plot on the left shows the former, that is, $\Delta\Pi_{TELCO,h} + \Delta\Pi_{f,h}$, and the plot on the right shows the latter, that is, the former plus $\Delta E[CS_h]$. Our results show that (on aggregate) firms lose more profit than what consumers gain in surplus when the length of the lock-in period reduces. For example, in a market with TELCO and 3 additional service providers, when the lock-in period reduces to 16 months, the net present value of the aggregated expected profits reduce more than \$40, which supersedes the increase in the present value of the consumer surplus of the representative household (\$2 $\sim$ \$22, as indicated above). Using the intuition laid out in section 4.3, this means that the costs incurred by firms to set up the households that churn because the length of the lock-in period reduces supersede the increase in the households' willingness to pay for service associated to the fact that the length of the lock-in period reduced. This figure also shows that these results remain unchanged for different consumer discount rates as well as for different rates of return.

XXX FIGURE 4 HERE XXX

6.2 Consumer Surplus When Firms Increase Prices

Our second set of simulations shows what happens if all firms increase prices (similarly) to compensate for the loss in profit due to the reduction in the length of the lock-in period enforced by the NRA, a phenomenon similar to the "water-bed" effect observed in telephony

(Genakos and Valletti, 2011). A "water-bed" effect may also arise in triple play markets because these markets include only a few firms who can strategically interact with each other[4]. In addition, in this set of simulations, and for sake of simplicity, we assume that firms increase the prices of all products by the same percentage points to keep their level of profitability (RoR).

Figure 5 depicts the results that we obtain and shows that consumers are worse off when the length of the lock-in period reduces if firms react by increasing prices to keep their profitability. For example, in a market with TELCO and other 3 competitors, the plot on the left shows that firms increase prices by roughly 1.5% to counter the loss in profit that arises when the length of the lock-in period reduces by 8 months. The plot on the right shows that in this case consumer surplus reduces \$4 $\sim$ \$15 depending on the discount rate. Therefore, consumers would have been better off if the NRA did not reduce the length of the lock-in period without preventing firms from increasing prices to counter the effect of such a policy on their profits. These results are similar for different consumer discount rates and for different rates of return for the firms, thus showing how reductions in the length of the lock-in period must be paired with price regulation, otherwise firms are likely to increase prices hurting consumers relative to the status quo of 24-months lock-in periods.

XXX FIGURE 5 HERE XXX

[4] If a market comprises only a few firms, the elasticity of the demand faced by one firm depends highly on the output of the other firms. Therefore, in this case, every firm has an incentive to coordinate and signal her behavior to the other firms.

7 Simulation Results with Reduced Prices

Our third set of simulations shows what happens if firms react to the reduction in the length of the lock-in period by reducing prices. This may happen, for example, because shorter lock-in periods allow consumers to churn more easily and thus firms may want to reduce prices to keep existing consumers. Then, when one firm reduces prices her competitors may also do so in response.

Figure 6 shows our results for when the length of the lock-in period reduces from 24 months to 16 months. As before, we assume that all firms discount the price of all products by the same percentage points. Our results show that when firm RoR and the consumer discount rate are comparable (for example when the latter in 0.075), the decrease in prices changes firm profits and consumer surplus similarly, thus leaving the total market welfare roughly unchanged. However, when firms discount the future less than consumers, which is usually what happens in the telecommunication sector (Yao et al., 2012), again firms lose more profit than consumers gain surplus. This result provides additional robustness to our previous finding. The total welfare in the market decreases when the length of the lock-in period reduces, irrespective of whether firms react by increasing or decreasing prices. Finally, appendix C shows similar results for when the length of the lock-in period reduces by less than 8 months, again providing additional robustness to our findings.

XXX FIGURE 6 HERE XXX

8 Conclusions

Lock-in periods in telecommunications services are a common practice employed by telecommunication providers to ensure that they cover the significant capital costs associated to build the network in the first place and to upgrade it over time. In short, operational revenues need to cover all operational costs and all investments in network upgrades as well as the initial cost to set up the network. The current practice is to lock-in consumers for periods of 24 months, which reduces uncertainty for the firm. Consumers pay financial penalties if they breach contracts while lock-in periods are still active. These penalties are set up by firms in ways that ensure that they still cover the costs mentioned above even when consumers leave early.

Telecommunication regulators have been studying the effect of lock-in periods on consumer welfare to regulate the former. Lock-in periods are a particular case of switching costs and thus they may hurt consumers because they reduce their freedom to change telecommunications provider. In line with this reasoning, regulators have been reducing the length of lock-in periods since the early 2000s and heated debate has recently ensued, once again, in several countries about reducing them further. Our paper uses a dataset from a large triple-play telecommunications provider to study what happens to consumers and to firms when the length of the lock-in period reduces from the current status quo of 24 months. We find that on aggregate firms lose more profit than what consumers gain in surplus when the length of lock-in periods reduce. This result shows that the increase in the consumers' willingness to pay for service associated to enjoying a shorter lock-in period (allowing consumers to churn earlier without paying a financial penalty) is superseded by the costs associated to set up service for the households that indeed churn due to the shorter lock-in period. In practice, a reduction in the lock-in period increases churn and firms incur this cost more often. Furthermore, the cost to set up triple play service to a new consumer is far from trivial.

Our study also shows that reducing the length of the lock-in periods may be insufficient to improve consumer well-being. Such a policy needs to be paired with price controls to further protect consumers. More specifically, our results shows that consumers become worse-off if firms react to a policy that shortens the length of the lock-in periods by increasing prices to keep their profits. We note that our results do not imply that regulators should not reduce the length of the lock in periods. In fact, doing so increases consumer surplus if firms are not allowed to increase prices to keep their profitability levels. However, regulators need to ponder between this increase in consumer surplus and the additional costs that firms incur to set up the consumers that churn. Also, regulators must anticipate that firms are likely to increase prices to cover such additional costs as a way to pass them along to consumers, which ends up hurting consumers relative to not changing the length of lock-in periods to begin with. Our work shows that regulators need to consider policies in tandem to achieve the desired goals. This insight may be of great value to telecommunication regulators now that a number of them are looking at considering changing lock-in policies.

Finally, we note that our paper has several limitations. First, we do not study what could happen if NRAs extended, instead of reduced, the length of the lock-in periods from the current status quo of 24 months. We only observe consumers locked-in for less than 24 months in our data and thus projecting what could happen with lock-in periods beyond 24 months would be extrapolating results outside the support of our data, an exercise that we cannot be confident of. In any case, studying how longer lock-in periods affect consumers and firms may be an object of future research. Second, our results are likely to generalize only to markets similar to the one that we empirically study in this paper using data from a single firm, that is, markets where firms offer homogeneous products, lock-in consumers for relatively long periods of time and where the cost to acquire consumers and set up service is not trivial. Examples of such markets include broadband and cable, wireless, security and surveillance, and other utilities such as energy, gas and water. Third, our simulations assume that when a consumer churns because the length of the lock-in period reduces she signs up for a similar service from a competitor in the same market. This might not be the case in all markets, such as cellphone service, where consumers may churn to upgrade their service.

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Table 1: Summary statistics for triple-play service bundles offered by TELCO.

No.	Share	N.channels	Internet	Telephony	Premium	Mobile	Avg.Price	Sd.Price	Best Price
1	0.20	$\simeq$ 120	$\simeq$ 30mbps	Yes	No	No	57.62	13.42	52.59
2	0.13	$\geq$ 160	$\geq$100mbps	Yes	Yes	No	64.73	5.71	62.57
3	0.12	$\geq$ 160	$\geq$100mbps	Yes	Yes	No	71.65	12.36	67.75
4	0.11	$\geq$ 160	$\simeq$ 30mbps	Yes	Yes	No	57.57	5.77	53.63
5	0.07	$\geq$ 160	$\geq$100mbps	Yes	Yes	No	73.41	4.04	69.51
6	0.07	$\geq$ 160	$\geq$100mbps	Yes	Yes	No	76.78	10.67	71.65
7	0.05	$\simeq$ 120	$\simeq$ 10mbps	Yes	No	No	58.68	4.77	51.08
8	0.04	$\simeq$ 120	$\simeq$ 10mbps	Yes	No	No	54.31	2.54	53.36
9	0.04	$\simeq$ 150	$\simeq$ 10mbps	Yes	No	No	57.16	4.49	54.59
10	0.03	$\geq$ 160	$\geq$100mbps	Yes	Yes	No	73.01	12.10	70.50
11	0.03	$\simeq$ 150	$\geq$100mbps	Yes	No	No	54.98	11.46	52.92
12	0.02	$\simeq$ 30	$\simeq$ 10mbps	Yes	No	No	51.99	0.10	51.99
13	0.02	$\simeq$ 30	$\simeq$ 1mbps	Yes	No	No	45.93	1.23	45.48
14	0.02	$\geq$ 160	$\geq$100mbps	Yes	Yes	Yes	101.97	11.40	100.31
15	0.02	$\simeq$ 150	$\simeq$ 10mbps	Yes	No	No	55.82	6.78	53.36
16	0.02	$\simeq$ 120	$\simeq$ 30mbps	Yes	No	No	58.67	3.85	57.65

(a) All monetary values are in 2013 US Dollars. (b) *Premium* is a dummy variable indicating whether the product contains premium features. (c) *Best Price* stands for the lowest introductory price available in the local market (zip-code) for a bundle with similar features offered by other service providers.

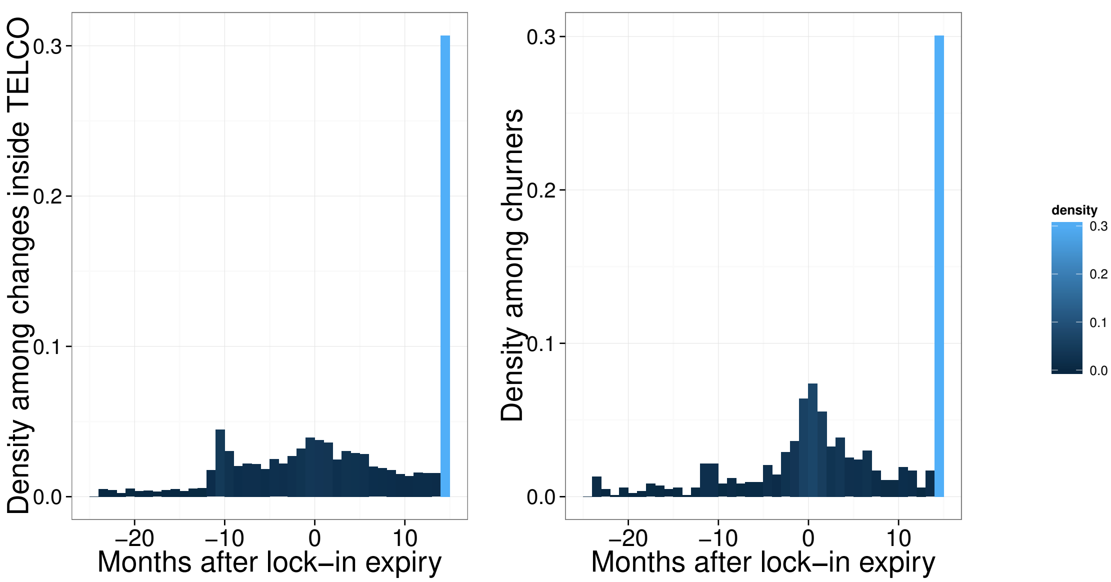

Figure 1: Density of changes inside TELCO and churn as a function of time to lock-in expiry.

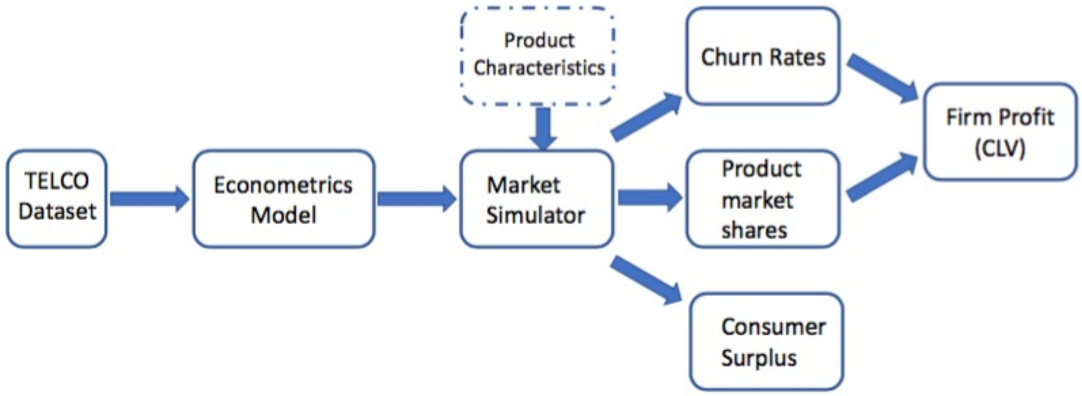

Figure 2: Flow chart for our policy simulations.

Table 2: Interpretation of the coefficients in our discrete choice models.

Label	Interpretation	Hypothesis
β	Effect of price on product utility	Negative sign. Utility reduces with price.
γ_1	Switching cost associated to changing bundle inside TELCO.	Negative sign. Switching costs negatively affect utility.
γ_2	Switching cost associated to churn when there is at most 1 month to the end of the current lock-in period	Negative sign. Same reason as above.
γ_3	Switching cost associated to churn when there is more than 1 month to the end of the current lock-in period	Negative sign. Same reason as above.
γ_4	Change in γ_3 with one more month of lock-in remaining	Negative sign. The more months remaining in the lock-in period the higher the switching cost.
γ_5	How γ_2 changes with the original length of the current lock-in period	Positive sign. Consumers may get tired of a longer contract and be more likely to churn when the contract has expired
γ_6	How γ_3 changes with the original length of the current lock-in period	No hypothesis made.
γ_7	How γ_2 changes with household tenure	Negative sign. Time keeps loyal customers. Users with longer tenure are less likely to churn.
γ_8	How γ_3 changes with household tenure	Negative sign. Time keeps loyal customers. Users with longer tenure are less likely to churn.
γ_9	How γ_1 changes with one more competitor in the local market	Positive sign. More competition likely leads to less switching costs.
γ_{10}	How γ_2 changes with one more competitor in the local market	Positive sign. More competition likely leads to less switching costs.
γ_{11}	How γ_3 changes with one more competitor in the local market	Positive sign. More competition likely leads to less switching costs.

Table 3: Switching cost estimates using our multinomial logit models.

	(1)	*(2)*	*Mixed Logit*	
	Mean Effect	Mean Effect	Mean Effect	Heterogeneity
Price (β)	−0.040***	−0.039***	−0.048***	
	(0.001)	(0.001)	(0.001)	
Change Inside(γ_1)	−6.600***	−6.611***	−7.411***	3.186 ***
	(0.057)	(0.020)	(0.052)	(0.306)
Change Outside × Contract Free(γ_2)	−8.616***	−8.778***	−9.646***	3.193 ***
	(0.210)	(0.212)	(0.322)	(0.153)
Change Outside × Contract Active(γ_3)	−8.729***	−8.933***	−9.805***	2.012***
	(0.383)	(0.386)	(0.459)	(0.239)
Change Inside × N Competitors(γ_9)	0.122***	0.122***	0.130***	
	(0.018)	(0.018)	(0.030)	
Change Outside × Contract Free ×	0.215***	0.226***	0.358***	
N Competitors (γ_{10})	(0.045)	(0.045)	(0.048)	
Change Outside × Contract Active ×	0.227***	0.243***	0.341	
N Competitors (γ_{11})	(0.089)	(0.090)	(0.093)	
Change Outside × Contract Active ×	−0.037***	−0.037***	−0.036***	
Month-to-contract-expiry(γ_4)	(0.016)	(0.016)	(0.016)	
Change Outside × Contract Free ×	0.023**	0.023**	0.042**	
Length-previous-contract(γ_5)	(0.005)	(0.005)	(0.006)	
Change Outside × Contract Active ×	0.010	0.010	0.013	
Length-previous-contract(γ_6)	(0.008)	(0.009)	(0.008)	
Change Outside × Contract Free × Tenure(γ_7)	−0.006***	−0.005***	−0.010***	
	(0.001)	(0.001)	(0.001)	
Change Outside × Contract Active × Tenure(γ_8)	−0.010***	−0.009***	−0.010***	
	(0.002)	(0.002)	(0.002)	
Number of channels	0.002***	0.003***	0.005***	0.000
	(0.000)	(0.000)	(0.000)	(0.003)
Internet speed	−0.004***	−0.004***	−0.005***	0.000
	(0.001)	(0.001)	(0.001)	(0.002)
Premium features	1.868***	1.868***	2.176***	0.012
	(0.042)	(0.043)	(0.060)	(0.149)
Mobile	1.424***	1.422***	3.118***	0.076
	(0.057)	(0.059)	(0.064)	(0.122)
Demographic Controls (μz)	*No*	*Yes*	*No*	
Observations (97,228 *Households*)	535,656	535,656	535,656	
Log-Likelihood	−179,386	−177,927	−176,955	
Mcfadden R^2	0.900	0.901	0.901	
Note:	·p<0.1;*p<0.5; **p<0.01; ***p<0.001			

Standard errors were robust clustered within households

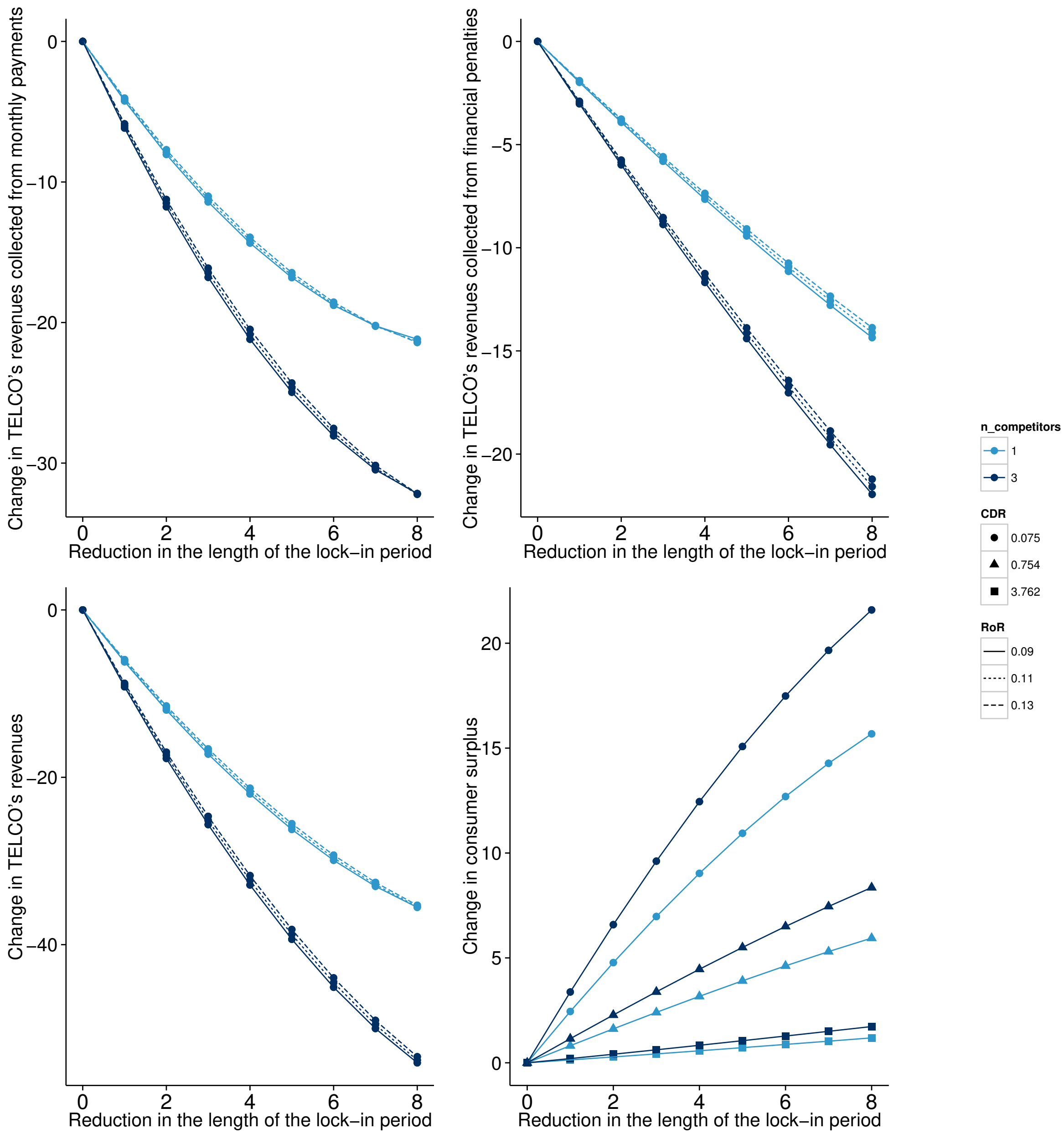

Figure 3: Change in TELCO's revenues collected from the representative household through monthly payments ($top - left$) and breaching penalties ($top - right$) as a function of the reduction in the length of the lock-in period relative to the status quo of 24 months. Change in TELCO's total revenues from this household ($bottom - left$) and change in the consumer surplus ($bottom - right$) as a function of the reduction in the length of the lock-in period relative to the status quo of 24 months. Results shown for when TELCO faces one 1 and 3 competitors, for different Consumer Discount Rates (CDR) and different Rates of Return (RoR) for TELCO. Plots are based on simulations using the estimation results in column (1) of Table 3.

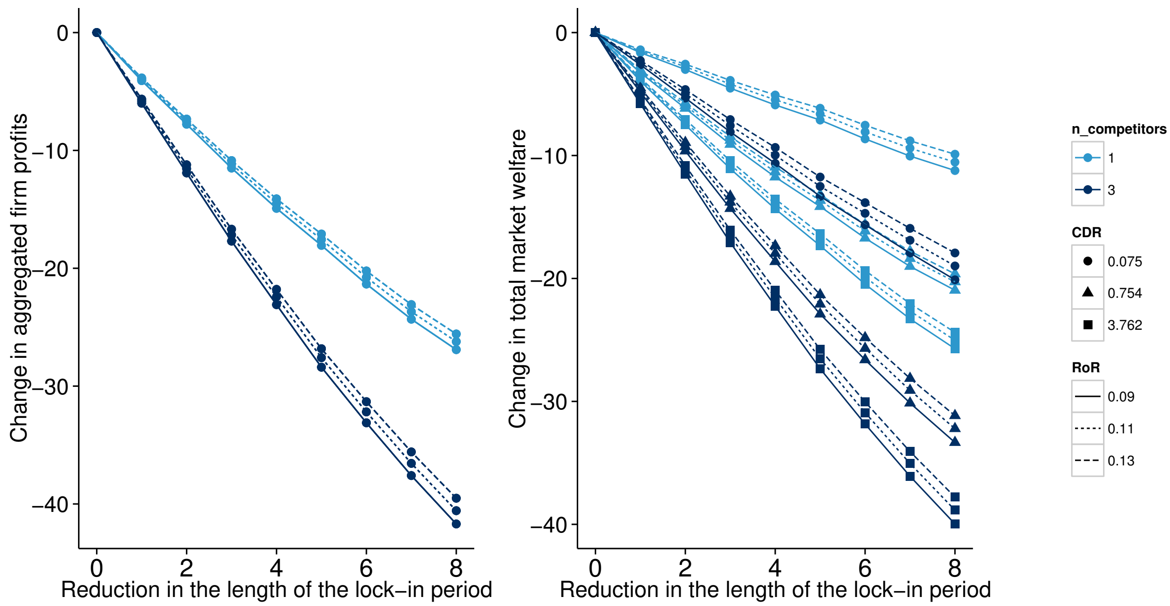

Figure 4: Change in aggregated firm profits ($left$) and in market welfare ($right$) as a function of the reduction in the length of the lock-in period from the status quo of 24 months. Results shown for when TELCO faces one 1 and 3 competitors, for different Consumer Discount Rates (CDR) and different Rates of Return (RoR) for TELCO. Plots are based on simulations using the estimation results in column (1) of Table 3.

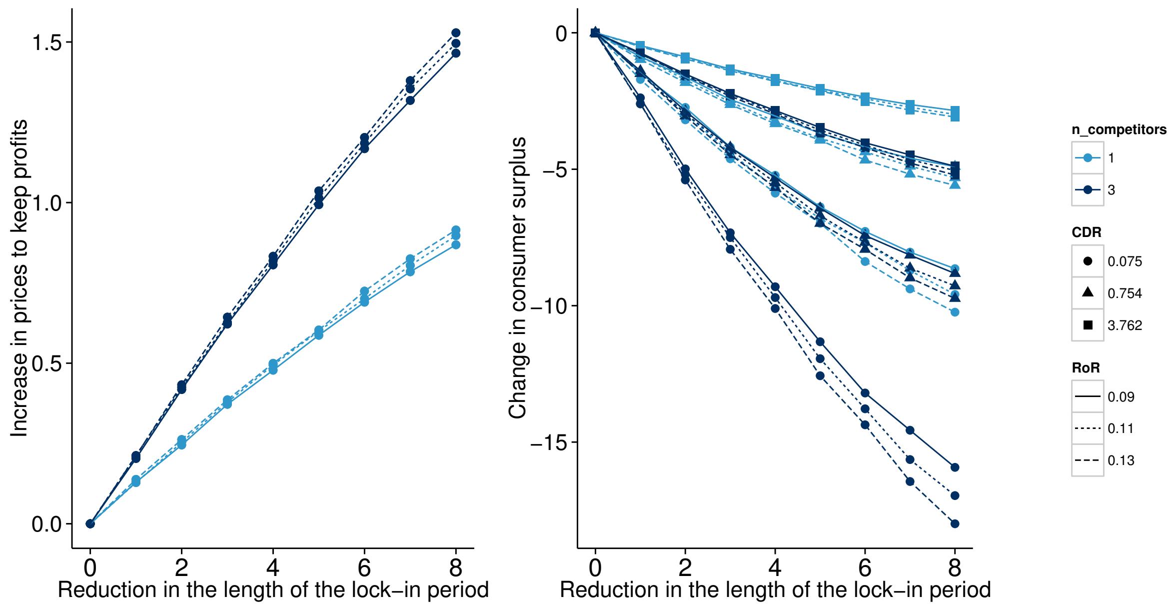

Figure 5: Percentage change in prices ($left$) and corresponding changes in consumer surplus ($right$) as a function of the reduction in the length of the lock-in period when firms increase prices to keep their profits, relative to the status quo of 24-month lock-in periods. Results shown for when TELCO faces one 1 and 3 competitors, for different Consumer Discount Rates (CDR) and different Rates of Return (RoR) for TELCO. Plots are based on simulations using the estimation results in column (1) of Table 3.

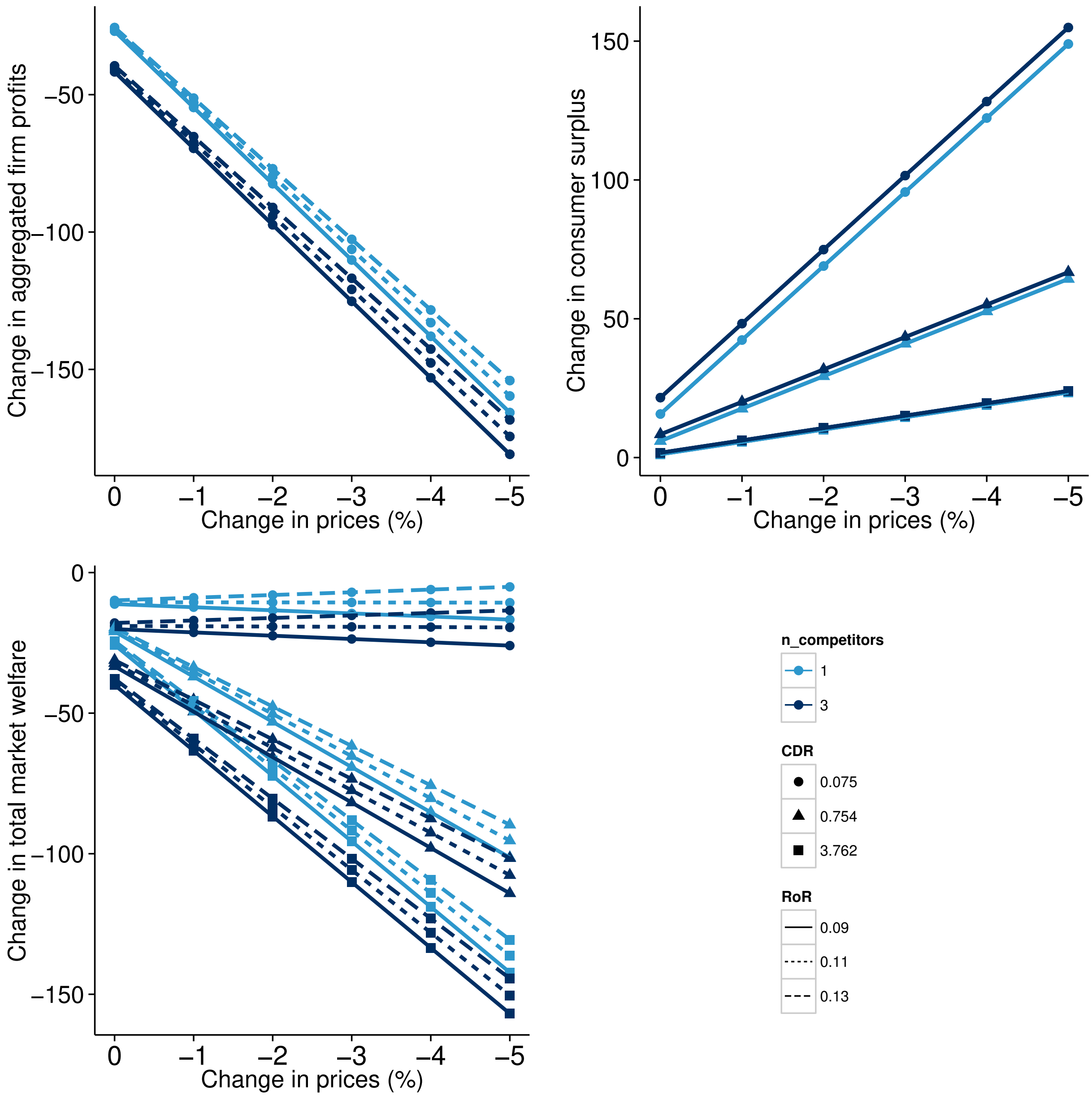

Figure 6: Effect of price decreases on aggregated firm profit (top-left), consumer surplus (top-right), and total market welfare (bottom-left) when the length of the lock-in period reduces from 24 months to 16 months. Results shown for when TELCO faces one 1 and 3 competitors, for different Consumer Discount Rates (CDR) and different Rates of Return (RoR) for TELCO. Plots are based on simulations using the estimation results in column (1) of Table 3.

A Estimation of Churn Rates

Figure 7 shows the churn and survival rates obtained from using our multinomial choice model to explain consumer behavior. In particular, the churn rate is given by the market share of the churn alternative as estimated in. column (1) of table 3. This figure shows that churn rates increase over time when the lock-in period is active. This is consistent with the fact that the financial penalty that customers need to pay to churn reduces as they near the end of the lock-in period. As expected, there is a significant increase in the probability of churn near the end of the lock-in period after which the likelihood of churn decreases smoothly because the customers that choose to stay with TELCO become increasingly more loyal over time.

This figure also shows results for different initial lengths of the lock-in period, which allows us to observe that the probability of churn increases for shorter initial lock-in periods because the latter embody smaller switching costs. However, after the lock-in period expires, consumers with shorter initial lock-in periods churn less. This is likely to arise because in that case churners drop out earlier and thus the customers that remain are less prone to churn. In addition, it may also be the case that consumers that were locked into longer initial lock-in periods perceive differently the limitations associated to being locked-in and become relatively more willing to churn when lock-in periods reduce.

This figure also shows the probability of churn for different numbers of competitors. In markets with more firms, the baseline probability of churn is higher because consumers experience smaller switching costs (γ_{10} and γ_{11} are positive and statistically significant in Table 3).

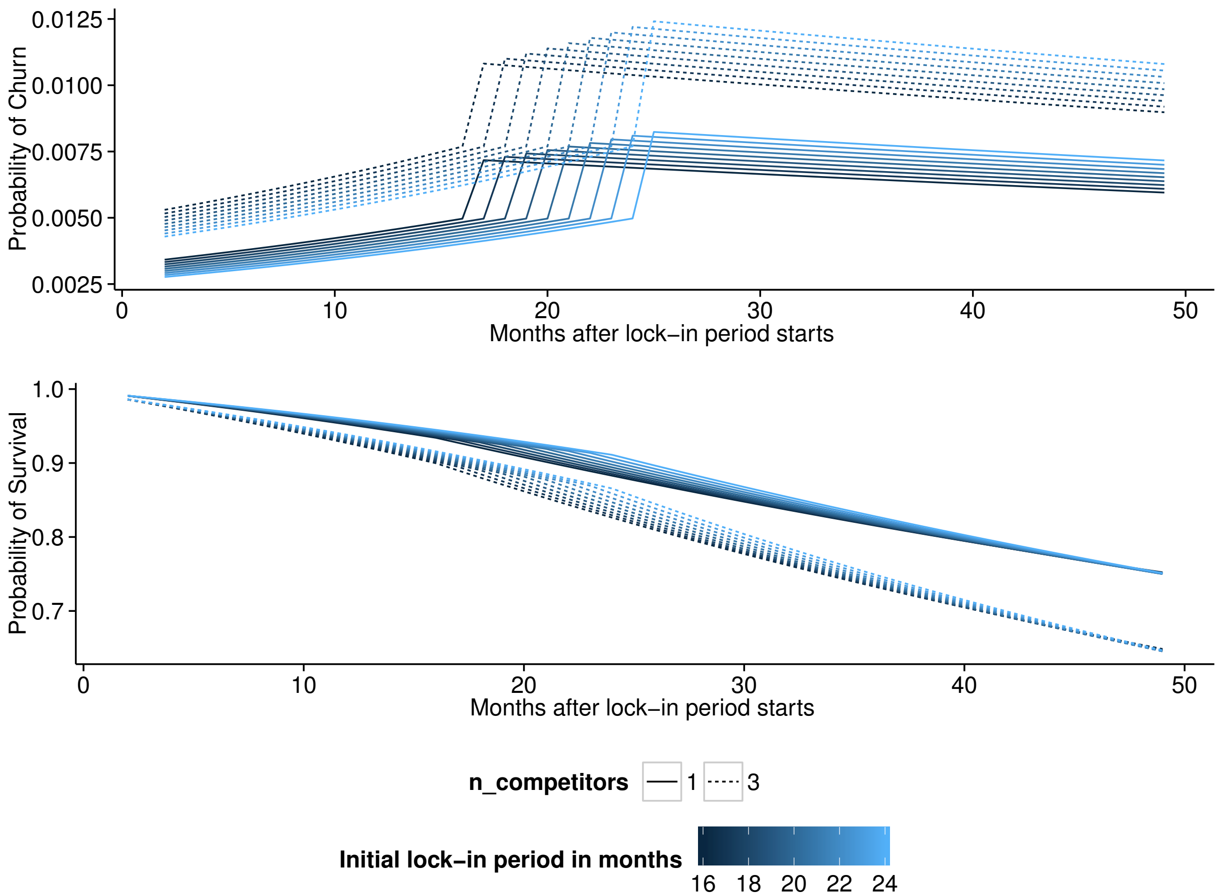

Figure 7: Estimated probability of churn (*top*) and probability of survival (*bottom*) when the length of the (initial) lock-in period varies. Results shown for when TELCO faces one 1 and 3 competitors. Plots are based on simulations using the estimation results in column (1) of Table 3.

B Simulation Results when Prices Change to Maintain Consumer Surplus

We also use our simulation framework to determine the increase in prices that would render consumers indifferent with respect to changes in the length of the lock-in period. In other words, we now consider the case when the NRA allows firms to increase prices to recover part of their profit loss, but only to the extent so that consumer surplus does not reduce. Figure 8 shows the results obtained. In the case of a market with TELCO and 3 other competitors and when consumers discount the future only slightly, the firm can increase prices by roughly 1% to counter a reduction in the length of the lock-in period of 8 months without hurting consumer surplus. This increase in price is about 60% of the increase in price needed by firms to maintain profit levels. However, when consumers discount the future significantly, firms would only be allowed to slightly increase prices to not hurt consumers, namely 0.25% for the case above.

These results show us that policy interventions to cap prices may be unnecessary when consumers discount the future substantially because the benefits from reducing switching costs are also smaller. These results are qualitatively similar for the different rates of return rates that we simulate. In sum, this analysis show how price regulation can be paired with reducing the length of the lock-in period to protect the surplus of consumers and, at the same time, protect also some of the firms' profits.

C Robustness Check for Simulations with Reduced Prices

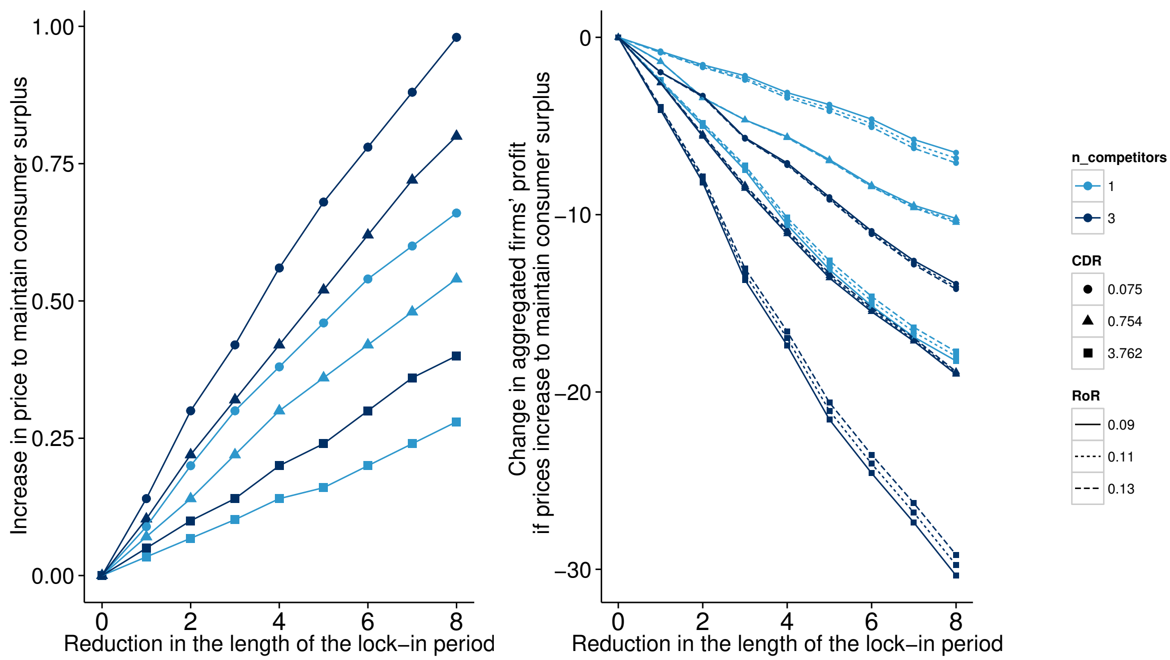

Figure 8: Increase in the price (in percentage terms) to keep consumer surplus unchanged (*left*) as a function of the reduction in the length of the lock-in period and associated loss in aggregated firm profits (*right*). Results shown for when TELCO faces one 1 and 3 competitors, for different Consumer Discount Rates (CDR) and different Rates of Return (RoR) for TELCO. Plots are based on simulations using the estimation results in column (1) of Table 3.

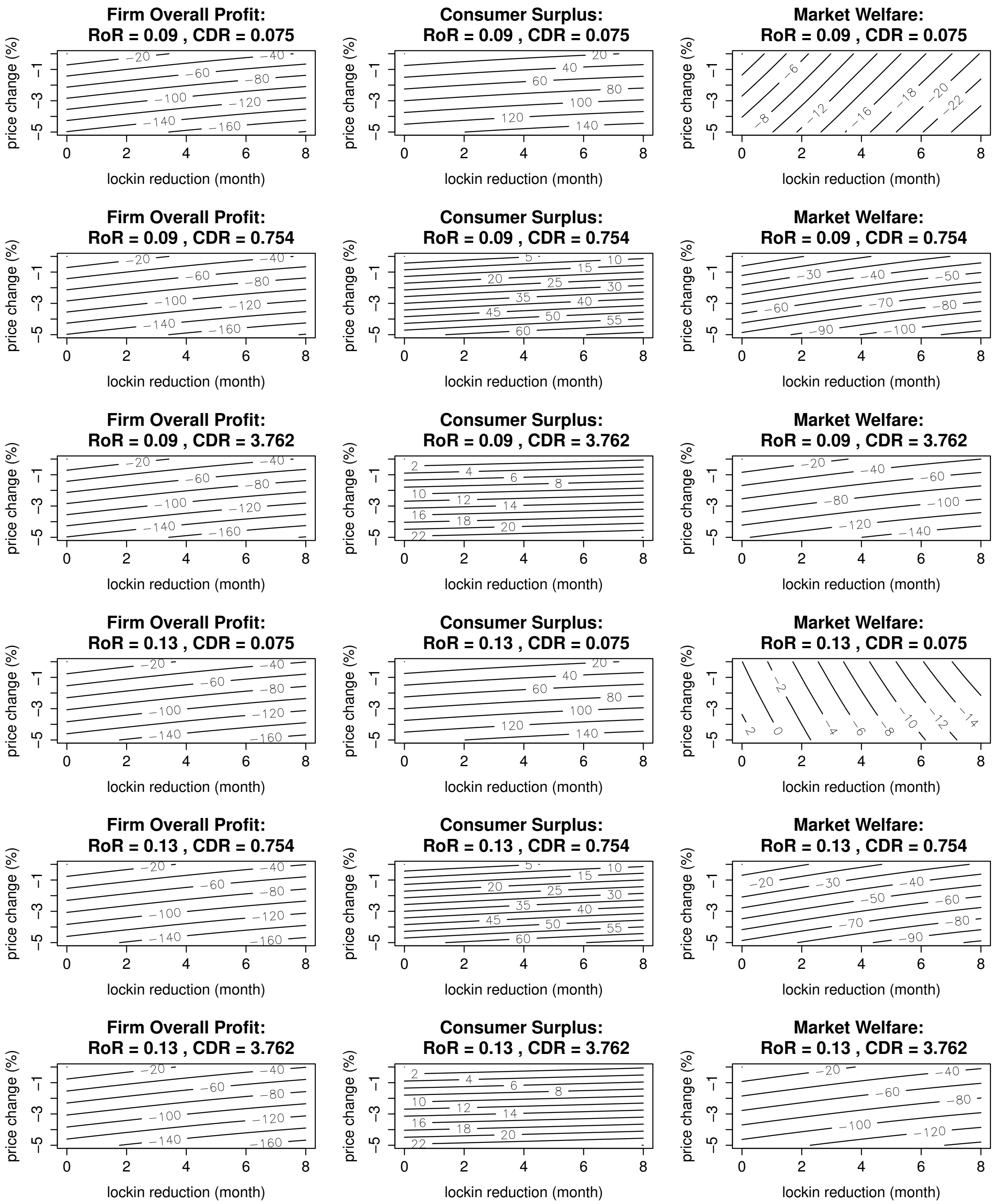

Figure 9: Contour plots for the joint effect of decreases in price (in percentage terms) and of reductions in the length of the lock-in period (in months) on aggregated firm profit (left column), consumer surplus (middle column), and total market welfare (right column) in a market with four providers. Results obtained using the estimation results in column (1) of Table 3.